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High Intensity Arc by Means of the Head-on Collision of Two Supersonic Jets

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The head-on collision of two supersonic jets in the arc was tested to intensify the arc brightness. Consequently, the temperature in the stagnation region of the arc and the arc brightness increased.

1. Introduction

Powerful arc lamps have the potential for surface treatments such as remelting, alloying, vitrification, etc. The purpose of this study is to produce higher temperature flows in the arc column. In this experiment, the head-on collision of two supersonic jets is utilized to elevate the temperature in the stagnation region of the arc column. This method may be expected to produce the following phenomena: first, when shock waves generate in the arc column and the gas develops irreversible adiabatic compression, temperature and pressure of the gas rise, and second, when the jets blow and constrict the arc, temperature and potential gradient of the arc column rise.

2. Experimental Conditions

Fig.1 shows the experimental apparatus. The combination of plasma torch and flat electrode was defined as "single torch" and the combination of plasma torch and plasma torch was defined as "twin torch". Either single torch or twin torch was placed vertically facing each other in the test chamber. Argon test gas of around 1.0 MPa was supplied to the nozzle in order to produce a supersonic flow. In order to study the behavior of the gas, ultra high speed camera whose minimum exposure time is 10 ns was used. The radiation was observed using a power meter and a spectrometer with ICCD.

Fig.2 shows shape of nozzles and visualization of gas by shadowgraph technique.Two kinds of micronozzles with 1.7 mm throat diameter, a normal and a Laval nozzle, were designed. The nozzles were tested to find the optimal conditions for the flow system. Mach number of the Laval nozzle was about 1.7, which was estimated by the ratio of total pressure to static pressure and Mach angle. The pressure in the stagnation region was estimated indirectly by means of stagnation pressure without electric discharge.

The temperature in the stagnation region was estimated by comparing the intensities of argon continuum. When the radiance was estimated measuring arc radiation intensity, the arc was regarded as perfect diffusing radiator of column or sphere.

The D.C. arc current was adjusted to around 60 A.

3. Results

Fig.3 shows the supply pressure dependence of temperature in the stagnation in case of twin torch. As the supply pressure increased from 0.4 MPa to 0.9 MPa, the temperature did not change greatly. The temperature in case of the Laval nozzle was about 15,000 K and around 3,000 K higher than that in case of the normal nozzle. The difference was caused by the conversion of the kinetic energy of the flow into the thermal energy. According to the compressible fluid theory, the gas temperature through the shock wave might rise to 20,000 K when Mach number of the supersonic flow was 1.7. The difference between the theoretical value and the data shown in Fig.3 was considered that the specific heat ratio became small because of argon ionization.

Fig.4 shows the radiance of the arc. The radiance in case of twin torch exceeded that in case of single torch. This was caused by the pressure rise in the stagnation region formed by opposed jets. In addition, the radiance in case of the Laval nozzle exceeded that in case of the normal nozzle. That was caused by irreversible adiabatic compression. It was effective to intensify the arc brightness in case of the Laval nozzles mounted on twin torch. The maximal radiance existed at the supply pressure when the gas through the Laval nozzle might expand correctly.

4. Conclusion

This paper deals with a new proposal to brighten arc. It is expected that the pressure and temperature in the stagnation region of the plasma torch were elevated by means of the head-on collision of two supersonic jets. The experiments to verify the validity of the principle were performed using plasma torches on which micronozzles were mounted. When the Laval nozzle was used to create supersonic flow instead of the normal nozzle, the temperature in the stagnation region was around 3,000 K higher and the radiance could be doubled. Maximal radiance was obtained for the optimally expanded supersonic flow. Therefore, it is considered that our proposal was effective for the intensification of arc brightness.

5. Acknowledgements

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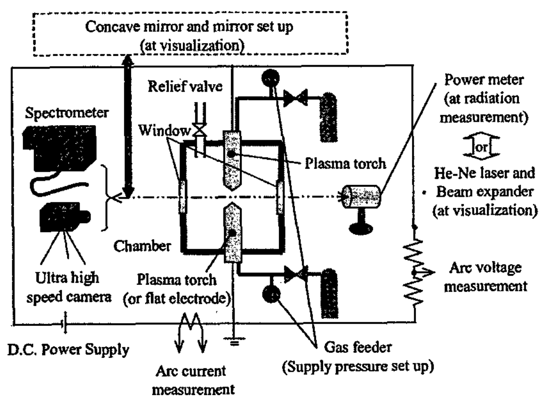

Fig.1 Schematic diagram of experimental apparatus.

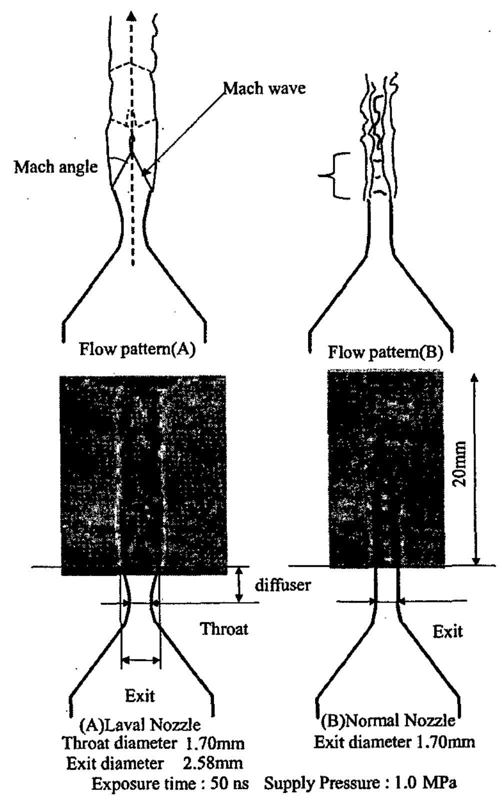

Fig.2 Shape of nozzles and visualization of gas by shadowgraph technique.

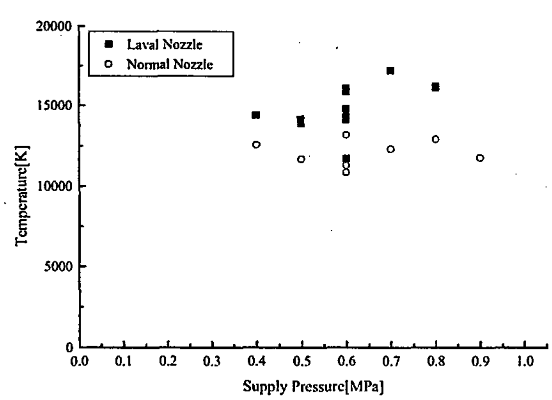

Fig.3 Supply pressure dependence of temperature.

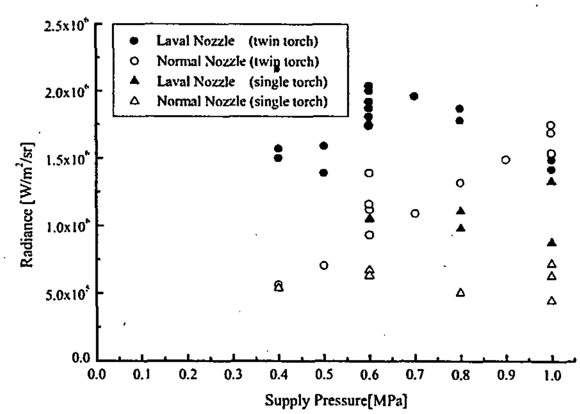

Fig.4 Supply pressure dependence of radiance.
(arc current : 50-70A)